Multi-objective design of single room ventilation units with heat and water recovery

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ABSTRACT

The project *Silenthalpic* aims at developing a new efficient single-room ventilation unit . A team of several industrial partners and research institutes tackles the acoustic, heat and moisture recovery as well as building integration challenge. To correctly reduce the sound emission level (i), a spectral analysis of the noise emitted by an existing unit was undertaken, revealing that frequencies under 1 kHz are mainly responsible for the noise disturbance. From this analysis, active and passive solutions for noise reduction are envisaged. The next research aspect is the exchanger of the ventilation unit (ii).

The constituting material is a new porous composite membrane allowing the humidity transfer (vapor or liquid). This specific exchanger is numerically modelled to predict its performance. The last challenge is the optimization of the ventilation and control strategies for the specific case of decentralized units (iii), taking advantage of sensors and recent communication technologies like IOT (Internet Of Things) to establish communication between decentralized units and ensure their consistent control.

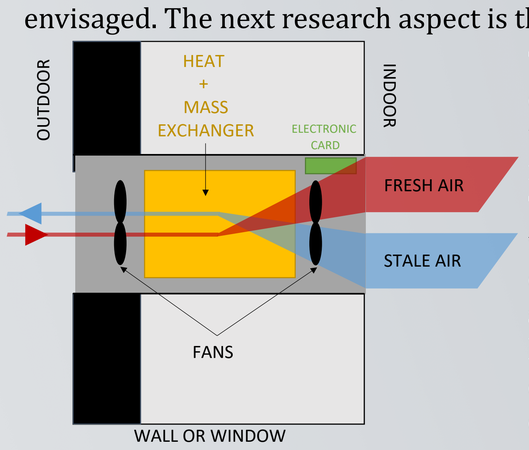

Figure 1: Schematic representation of the unit

OBJECTIVES

- **Noise disturbance limitation**. As the solution is decentralized, fans are in the actual living rooms (bedrooms, offices,...) and the noise generated must be limited. Specific efforts are deployed to maintain the acoustic disturbance linked to the use of fans as low as possible. Moreover, the ventilation unit is prone to increase the transmission of outdoor noise emissions to the building's interior. Acoustic insulation properties in the unit should be evaluated from an existing unit to find the best way to improve the performance for the new one (target : 35dBa at 50 m³/h).
- **Enthalpy exchanger** development. In addition to recover heat, it also recovers a part of the moisture from the extracted stale air.
- Development of a so-called "**evolutionary**" ventilation system.

REDUCTION OF NOISE EMISSIONS

EXPERIMENTAL DIAGNOSIS OF EXISTING UNIT

A vibro-acoustic evaluation of the ventilation unit in its current state. Set-up realized in an anechoic room with a similar ventilation unit which was inserted into a big baffle → measure the directivity of the sound emission by each fan, in several third-octave bands. Results : emission close to omnidirectional, for the frequency interval of interest

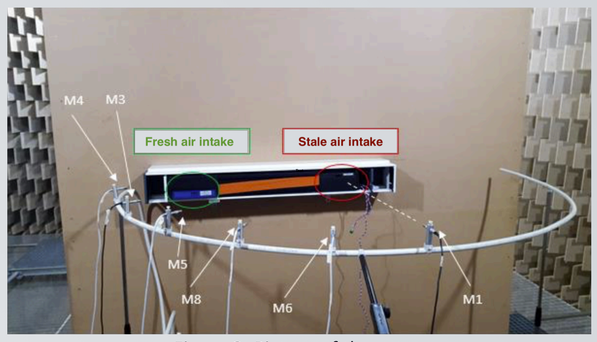

Figure 2: Picture of the setup

Passive noise attenuation: Application of absorbing materials at well-defined locations : up to 7 dB(A) gain but space limitation issues

NUMERICAL MODEL

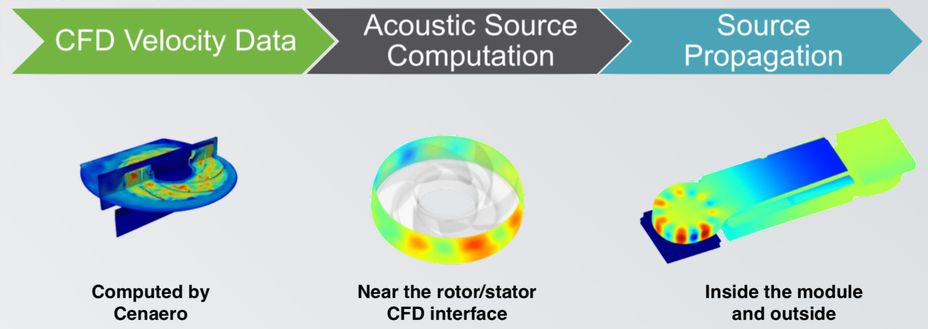

Figure 3: Different steps in numerical investigation

Passive noise attenuation: optimize the whole geometry setup of the unit to limit noise emissions:

- fan's volute
- components implementation
- prohibited fan speeds, ...

Active noise attenuation: secondary acoustic wave (destructive) generated by an actuator (generally a loudspeaker) to superpose the primary (noise) wave. Strategic locations must be defined for the two microphones and the loudspeaker (use of numerical model)

HEAT AND MOISTURE RECOVERY EXCHANGER

- Robust materials
- Permeable to humidity
- High enlargement factor (i.e. ratio between developed and flat surfaces)
- **Composite membrane** : inject solid particles into a polymer matrix to artificially create defects

Experimental apparatus to evaluate liquid water permeability : weight a water tank initially and after 24 hours in a controlled atmosphere. Water is separated by the actual membrane. Role of the sponge : ensure liquid contact.

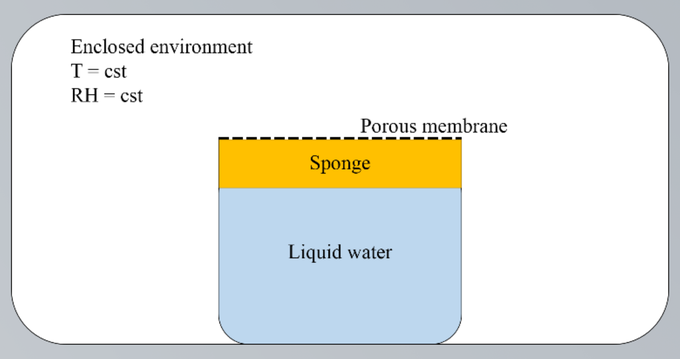

Figure 4: Experimental setup used for the determination of the membrane permeability

Implementation of **numerical model**. First model to account for liquid transfer (in case of condensation) in addition to vapor transfer.

Goal : supply different geometries with specific constraints to the model and to assess which one will be produced and implemented in the actual demonstrator

DESIGN AND CONTROL AT BUILDING SCALE

- Multizone simulations were performed with the CONTAM software to evaluate the impact of decentralized ventilation on the overall energy performance

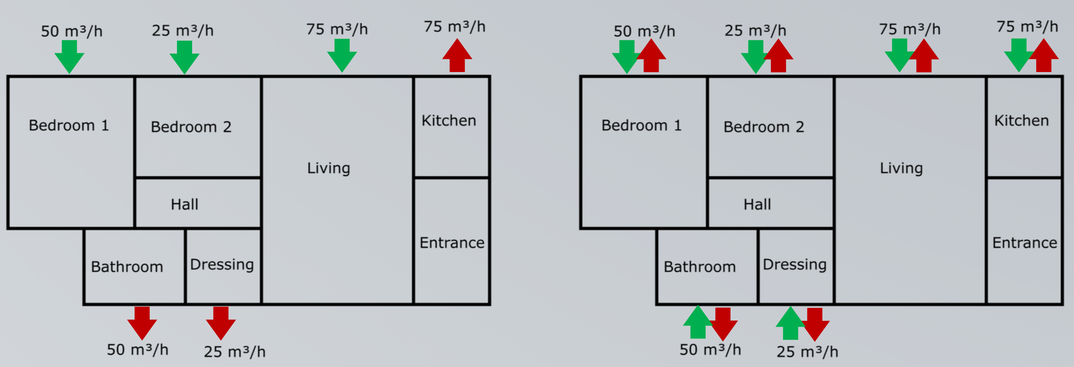

Figure 5 : Flow rates for a conventional mechanical system (left) and a fully decentralized system (right).

Case	Nominal flow rate [m³/h]	Mean flow rate with local regulation and detection [m³/h]
Conventional centralized system	150	63
Fully decentralized system	300	86
Remote extraction decentralized system	150	66

Table 1: Mean flow rate of the DCV strategy for different ventilation designs based on (NBN D-50-001)

- An electronic card has been designed and prototyped with the ability to support all types of required sensors (temperature, pressure, CO2, etc) and to communicate with other units through the Zigbee protocol.

CONCLUSIONS/PERSPECTIVES

- Good diagnosis of the different technologies
- Many different leads to deeper investigate the unit
- Objective to design a decentralized ventilation unit with low noise emissions, which is efficient and intelligent is reachable for the end of the 2nd part of the project

The consortium would like to thank the Walloon Region and the Pole Mecatech [convention 7711] for the support in this work.

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